AD-A203 039

NOSC TD 1216

NOSC

NAVAL OCEAN SYSTEMS CENTER San Diego, California 92152-5000

NOSC TD 1216

Technical Document 1216
February 1988

Menuing and Scrolling as Alternative Information Management Techniques

S. S. Osgood
University of South Dakota

Approved for public release; distribution is unlimited.

NAVAL OCEAN SYSTEMS CENTER
San Diego, California 92152-5000

E. G. SCHWEIZER, CAPT. USN
Commander

R. M. HILLYER
Technical Director

ADMINISTRATIVE INFORMATION

This work was performed for the Navy Personnel Research and Development Center, San Diego, California 92152-6800, under program element 62757N. Contract N66001-85-C-0253 was carried out by the Human Factors Laboratory, Department of Psychology, University of South Dakota, Vermillion, South Dakota 57069, under the technical coordination of G.A. Osga, Code 441, NAVOCEANSYSCEN.

Released by
C.M. Dean, Head
Human Factors and
Speech Technology Branch

Under authority of
W.T. Rasmussen, Head
Advanced C² Technologies
Division

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a REPORT SECURITY CLASSIFICATION: UNCLASSIFIED	1b RESTRICTIVE MARKINGS
2a SECURITY CLASSIFICATION AUTHORITY	3 DISTRIBUTION/AVAILABILITY OF REPORT: Approved for public release; distribution is unlimited
2b DECLASSIFICATION/DOWNGRADING SCHEDULE	
4 PERFORMING ORGANIZATION REPORT NUMBER(S)	5 MONITORING ORGANIZATION REPORT NUMBER(S): NOSC TD 1216
6a NAME OF PERFORMING ORGANIZATION: Human Factors Laboratory, Department of Psychology; 6b OFFICE SYMBOL (if applicable)	7a NAME OF MONITORING ORGANIZATION: Naval Ocean Systems Center
6c ADDRESS (City, State, and ZIP Code): University of South Dakota, Vermillion, South Dakota 57[illegible]	7b ADDRESS (City, State, and ZIP Code): Human Factors and Speech Technology Branch, San Diego, California 92152-5000
8a NAME OF FUNDING/SPONSORING ORGANIZATION: Navy Personnel Research and Development Center; 8b OFFICE SYMBOL (if applicable): NPRD-NA	9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER: N66001-85-C-0253
8c ADDRESS (City, State, and ZIP Code): San Diego, California 92152-6800	10 SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO	PROJECT NO	TASK NO	AGENCY ACCESSION NO
62[illegible]N	[illegible]	440-CE0[illegible]	DN68[illegible]511

11 TITLE (Include Security Classification)
Menuing and Scrolling as Alternative Information Management Techniques

12 PERSONAL AUTHOR(S)
S.S. Osgood

13a TYPE OF REPORT	13b TIME COVERED	14 DATE OF REPORT (Year, Month, Day)	15 PAGE COUNT
Interim	FROM Feb 1986 TO Aug 1986	February 1988	92

16 SUPPLEMENTARY NOTATION

17 COSATI CODES		
FIELD	GROUP	SUB-GROUP

18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
menuing, scrolling, touch tablet, motor skills, data entry devices, hierarchical menu structure, spatial data management system (SDMS), user-computer interface, human performance

19 ABSTRACT (Continue on reverse if necessary and identify by block number)

An experiment was conducted to evaluate menuing and scrolling as alternative information management techniques. A menu structure (4-3) and three scrolling methods, line-by-line, half-screen, and full-screen, were tested. Level of goal word familiarity and size of display window were also examined. The task consisted of locating a target goal word with one of the four access methods. A touch tablet was used to interact with the computer system. Members of a single set of 64 words, 32 familiar and 32 unfamiliar, served as goal words in all conditions. Performance data were collected from 48 subjects. Each subject received both word familiarity levels. Access method and window size were between-subjects variables.

Results of an analysis of variance on mean total task time revealed significant access method, word familiarity, and access method by word familiarity interaction effects. Line-by-line scrolling was fastest, followed by full-screen scrolling, half-screen scrolling, and menuing.

Separate analyses of variances were conducted on total task time for familiar and unfamiliar word sets. The fastest condition depended on the familiarity level of the goal word, but not on window size. When the goal word was familiar, menuing was fastest, followed by line-by-line, full-screen, and half-screen scrolling. For unfamiliar goal words, line-by-line scrolling was fastest, followed by full-screen scrolling, half-screen scrolling, and menuing.

To examine subjects' performances in more detail, supplemental time measures were recorded as well as indices reflecting the number of times the various buttons were pressed. Descriptive statistics and regression analyses were presented and discussed. Questionnaire data regarding menuing and scrolling experience, number of computer science classes taken, and biology background relating to the four major categories were also collected and analyzed.

20 DISTRIBUTION/AVAILABILITY OF ABSTRACT: ☐ UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT ☐ DTIC USERS	21 ABSTRACT SECURITY CLASSIFICATION: UNCLASSIFIED
22a NAME OF RESPONSIBLE INDIVIDUAL	22b TELEPHONE (Include Area Code)

DD FORM 1473, 84 JAN

83 APR EDITION MAY BE USED UNTIL EXHAUSTED
ALL OTHER EDITIONS ARE OBSOLETE

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

Glossary of Abbreviations

M1PAUSE	Scrolling conditions: Mean time from initial presentation of the goal word to the first PAUSE button press
M2PAUSE	Scrolling conditions: Mean time from first PAUSE button press to final PAUSE
M3PAUSE	Scrolling conditions: Mean time from final PAUSE button press to selection of the goal word
M1PRS	Menuing condition: Mean time from initial presentation of the goal word to the first button press
MLINEB1	Scrolling conditions: Mean number of lines scrolled backward after the PAUSE button was pressed the first time
MLINEB2	Scrolling conditions: Mean number of lines scrolled backward after the second time the PAUSE button was pressed
MLINEF1	Scrolling conditions: Mean number of lines scrolled forward after the PAUSE button was pressed the first time
MLINEF2	Scrolling conditions: Mean number of lines scrolled forward after the second time the PAUSE button was pressed
MNUMPAUSE	Scrolling conditions: Mean number of times the PAUSE button was pressed during a trial
MPE1	Menuing condition: Mean path error-one level--the number of times the subject backed up one level of the menu hierarchy
MPE2	Menuing condition: Mean path error-two levels--the number of times the subject backed up two levels of the menu hierarchy
MTIME	Dependent measure: Mean total task time

CONTENTS

LIST OF TABLES

LIST OF FIGURES

Introduction

Much contemporary systems research is focused on the organization and management of information so that the demands imposed on the computer users are not overwhelming. The systems researcher is also faced with an increase in the diversity of users. Users vary along many dimensions: the extent of their knowledge of different tasks; their motor skills with various data entry devices; their general technical aptitude for using computer systems; and their experience with the system. Novice users would know little about the system; casual users would know a moderate amount about the system, but might use it at irregular intervals; and expert users would have a detailed knowledge of the system and use it frequently (Moran, 1981; Card, Moran, and Newell, 1980). The introduction of on-line systems in many industrial, academic, and public service environments has widened the number of non-specialists who use the computer as a tool. Indeed Shneiderman (1980) reported that non-programmer clerks, managers, and casual users now outnumber programmers as users of computer terminals. Careful consideration, then, must be given to the human-computer interface.

The human-computer interface is the intersection of hardware, software, and the user (Bo, 1982). Some of the hardware interface considerations are the displays, controls, terminals, consoles, and data entry devices. Also important are the basic characteristics and limitations of the computer system such as computing capacity, speed, system response time, reliability, and language facilities. The software interface involves the non-hardware communication aspects including language and linguistic systems and information organization, i.e., logical structure of the content and procedures, the message structure and wording, display format, and layout (Shakel, 1980). The human component is concerned with user performance and is affected partly by physical factors such as eye-hand coordination, motor skills, and visual acuity, but also by cognitive factors such as short-term memory capacity, long-term memory organization, problem solving ability, and learning styles (Allen, 1982; Grimes, 1979).

A number of techniques have been developed for managing the information in computer systems. In the literature these techniques are generally referred to as types of human-computer dialogue or interface modes. The dialogues are composed of two parts: the computer aspect, determined by the software, and the human

aspect, any user input to the system (Johnson and Hartson, 1982). Martin (1973) listed 18 main types of interactive human-computer dialogue and cited advantages and disadvantages of the different methods depending on the type of user. Ramsey and Atwood (1979) summarized and expanded the earlier work of Martin and identified eight interactive dialogue types which include: question-and-answer dialogue, form-filling, query language, natural language, user-initiated command language, menu-selection, and interactive graphics. Scrolling is another method of information management.

With a multifunction CRT to display alphanumeric information, the operator observes and controls the system through a confining window which allows access to only a limited amount of information at a given time (Miller, 1981). The method by which this window probes the system can affect user-system performance. Menuing and scrolling represent alternative methods for accessing information in computer systems.

Menuing

Menu-selection is a widely employed information management technique. The range of items which can be selected appear directly on the display. The user then selects an option and the program branches to the

subroutine that corresponds to the user's choice and displays the new menu of options available at that point. This process repeats itself until the user activates a specific operation A main advantage of this method has been that menu selection is generally considered easy to use by naive or first-time users because no special vocabulary needs to be learned (Tombaugh and MacEwen, 1982). The user only has to know and understand the currently available options because the program offers prompts at each stage (Hauptmann and Green, 1983). Unlike the question-and-answer and form-filling techniques, the user of the menu-selection technique need only recognize the desired action, not produce it (Dumais and Landauer, 1982; Tombough and McEwen, 1982). Menus structure information retrieval, thereby reducing the need for training. However, menuing structures are usually quite inflexible, providing only a single path to a given target item (Dumais and Landauer, 1982).

Menu structures conform to various database models used by system designers to organize information. "The data model consists of the structures which can be described in the data definition language and the operations provided by the data manipulation language" (Shneiderman, 1980, p. 144). The major database models are relational, hierarchical, and network data models.

The relational model is based on the mathematical theory of relations whereby the data are structured according to a two-dimensional, orthogonal table where each column contains values from a single domain. The rows of the relation under each column are called tuples. The tables must be set up in such a way that no information about the associations between the data items is lost. According to Shneiderman (1980) and Martin (1977) the relational model has a few simple organizational rules: 1) no two tuples (row of relations) can be the same; 2) the order of the tuples does not matter; 3) each column must be assigned a distinct name; 4) the order of the columns does not matter as long as the column name is kept with the column values.

The hierarchical data model is based on tree-structured data relationships. A tree is composed of hierarchy of elements called nodes. The uppermost level of the hierarchy has only one node which is called the root. All nodes except the root are related to only one node on a higher level than themselves--a one-to-many relationship. The hierarchical model is easy to understand, but limits the complexity of the possible data relationships (Martin, 1977; Shneiderman, 1980). The hierarchical model is excellent for simple tree-structured relationships, but is not the

organizational strategy to use if complex relationships among the data items must be preserved.

The third major database model is the network model, which has a more sophisticated data structure than the hierarchical model. While the hierarchical model employs a one-to-many relationship, the network model permits additional linkages which can employ many-to-many relationships. Thus, any item in the network can be linked to any other item (Martin, 1977) and nodes may have multiple roots. The full network has many additional features for organizing information and searching efficiently.

Overall, the choice of an appropriate database depends primarily on two considerations. Durding, Becker, and Gould (1977) have concluded that "the conceptual structure of the database should conform to the semantic relationships among the data elements. If the data concern the hierarchical structure of a business, then the user should be able to manipulate the data mentally according to principles of hierarchical organization and safely assume and expect the retrieval system can and will do likewise." Second, "the language used to interrogate the database should allow for the direct expression of the different types of relationships" (Durding et al., 1977). Hierarchical, network, list, or table structures should

be available so that the information is presented in a physical format consistent with the semantic relationships within the database. In the present investigation the hierarchical or tree structure is used because of the experimental evidence favoring such a structure and because of the natural hierarchical structure of the data (Brosey and Shneiderman, 1978; Durding et al., 1977; Savage, Habinek, and Barnhart, 1982).

The hierarchical menu structure of this study has four items on each of three levels of menus (a 4-3 tree structure). This structure was chosen after a review of the literature on depth-breadth trade-off issues in menu design and the related display density issue. Given a fixed number of goal words, the hierarchy can be arranged with many items on each menu and a minimum number of sequential menus (broad), with few items on each menu and several levels (deep), or anywhere between these two positions. If the system has great breadth, the user has to search through many items at each level to locate the goal word. The visual search literature indicates that response time increases linearly with the number of items displayed (Shulman, 1971; Baker, Morris, and Steedman, 1960; Drury and Clement, 1978; Neisser and Beller, 1965; Monk and Brown, 1975). However, the alternative approach of

increasing depth at the expense of breadth also presents problems. Short-term memory limitations suggest that path lengths of more than five items are difficult to remember (Miller, 1956; Atkinson and Shiffrin, 1968; Allen, 1983). Thus, an increase in either depth or breadth increases goal acquisition time. Systematic attempts have been made to investigate the trade-off between the two variables (Miller, 1981; Snowberry, Parkinson, and Sisson, 1983; Kiger, 1984). These studies used four menu hierarchies developed by Miller (1981), each with 64 words at the lowest level. Depth was varied from one to six, while breadth was varied from two to 64. The results indicated that the intermediate levels, 4-3 and 8-2, produced the fastest goal-acquisition times. In the Kiger (1984) study the 8-2 tree structure was the most efficient. He stated, however, that the slower task time was associated with the 4-3 tree structure "may be only an artifact of including the system response time in the calculations" (Kiger, 1984). The other two studies did not include the system response time. Lee and MacGregor (1985) also examined the optimal structuring of menu indexes in computerized information retrieval by using a simulation program. For a wide range of conditions, the optimal number of alternatives per page was detemined to be from four to eight. Thus,

the 4-3 tree structure of the present investigation was a satisfactory menu structure to compare with the scroll function structures.

Scrolling

Scrolling is a related information management technique used to organize access to various portions of a database. Scrolling is used to display data that is located beyond the limits of the screen. With menuing the user essentially "pages" through an organized data set, whereas with scrolling the data is presented sequentially in a designated window.

One advantage of scrolling is that a single response selects an item, unlike menuing where multiple responses are typically required. Also, the user need not remember which item calls up which other item, as in a menu. Another advantage is that users unfamiliar with information in the system might not get lost as easily since the information is presented sequentially.

One other advantage of scrolling relates to the use of alternative input devices. If space is limited on the computer screen, more lines of information will fit into the same window than would be possible using touch-sensitive areas corresponding to menu choices on the screen. For example, the minimum "button" size for using a touch screen or other alternative input devices

is about 3 lines. If the work area is 12 lines on the screen, then only 4 touch sensitive "buttons" would fit, whereas 12 lines of scrolled information could be displayed. However, as the list of information to be scrolled grows longer the advantage of having more information per screen disappears. Thus, the main disadvantage of scrolling for managing information is that very long lists increase system response time to unacceptable levels as compared with that of a menu structure--assuming the user chooses the correct path to the desired information.

There are two ways to conceptualize scrolling. One visualizes the data as if it is moving behind a stationary CRT. Bury, Boyle, Evey, and Neal (1980, 1982) use the analogy of the biologist moving (scrolling) the slide beneath a stationary microscope. To display data currently beyond the upper limit of the display screen, the user would use the "scroll down" command which moves the data down bringing the requested information into view. In the same way, to view information beyond the left border of the screen the user would use the "scroll right" command to move the data to the right (Bury et al., 1982).

In an alternative way to conceptualize the scroll function, a person visualizes the display screen as if it were a moveable "window" through which the

stationary data could be viewed. Bury et al. (1982) use the analogy of the astronomer moving (windowing) the telescope across the sky. With this kind of scrolling concept, the user would issue a "window up" command to display data located beyond the upper border of the display screen. Likewise, the user would utilize the "window left" command to view data beyond the left border of the display screen.

Research by Bury et al. (1980, 1982) reported that subjects preferred the windowing mode and performed significantly faster and with fewer moves than did subjects in the scrolling groups. Other research (Happ and Lewis, 1983) found that a significantly greater proportion of users with experience in the control of data preferred to scroll, although no performance data were collected. Although the subjects in the Happ and Lewis experiment preferred scrolling, it should be noted that the subjects in this study most likely learned initially on computer systems utilizing the scrolling concept. The present study used the "scrolling" concept rather than the "windowing" concept, and to avoid confusion among the subjects, the command "buttons" were clearly labelled.

A variety of methods can be used to implement the scrolling technique. When the information moves continuously it is called pan scrolling (Schwarz,

Beldie, and Pastoor, 1983). One major system that uses the continuous scrolling technique is the Spatial Data Management System (SDMS). In this system scrolling is performed by changing the point in the buffer at which the display refreshes the screen while simultaneously writing new data into that refresh buffer, producing a continuous presentation of the text (Herot, Kramlich, Carling, Friedell, and Farwell, 1978; Friedell, Kramlich, Herot, and Carling, 1979). Visually, the text moves smoothly on the screen and does not "jump".

Most systems use line-by-line scrolling in which one line of new information appears on the bottom of the current window as one line of the previously viewed information scrolls off the top of the window. Other text-editors use a half-screen or full-screen scroll method to move and view the information. With the half-screen scroll method, the information scrolls continuoulsy half a screen at a time. On each screen the text appearing on the top half of the screen (window) scrolls off the top of the window and the text on the bottom half of the screen moves up to the top half of the screen. Meanwhile, the next half-screen of information appears on the bottom half of the screen. The result is that previously viewed text appears in the top half of the window, while the new text appears in the bottom half of the window. The advantage of

this technique is that a sense of context is maintained. The disadvantage might be that the information may seem to "jump" around on the screen.

The full-screen scroll method consists of having the information scroll continuously a whole screen at a time (except for the last line of the previously viewed text, which would give context). This method is similiar to the paging mode discussed below.

Despite its display capabilities, scrolling has received only limited empirical investigation. Scrolling is widely used in motion pictures and on television to display credits at the end of films, but the author did not find any published reports discussing different ways of implementing the scroll or preferred rates of presentation involved in such application. The available research mostly compares paging and scrolling. Under a paging operation, each screenful of stationary text is followed by another when the reader signals the system. The presented information is changed all at once. With scrolling information moves continuously until the user stops the process.

Schwarz et al. (1983) compared paging and scrolling for changing screen contents by inexperienced users. Three tasks (word reading, line searching, and sorting) were performed by the subjects using both the paging

and scrolling methods of operation. The line searching task, in which a given term was to be found in a list of 16 terms, and the sorting task, in which twenty terms were to be put in alphabetical order, were of the most interest to the present investigator because the tasks were similar to that employed here. The subjects also rated the suitability of the two modes of operation for each task. The results indicated that paging was preferred by inexperienced users and it resulted in better performance on the sorting task. No significant difference was found between paging and scrolling on the line searching or word reading tasks.

Another experiment evaluated strategies of interactive file search (Elkerton, Williges, Pittman, and Roach, 1982). Five computerized search procedures were studied to evaluate selection frequency and search efficiency. The search procedures were: scrolling, paging, string search (Find), absolute line movement (line number), and relative line movement (lines up and down). The search strategies were assessed with respect to five independent variables: file type (data or text), file length (45 or 200 lines), window size (1, 7, 13, and 19 lines), target type (words, phrases, or digits), and subject experience (novice or expert). The results indicated that experts and novices used different search strategies. Experts typically relied

on string search procedures (Find), while novices used a variety of search procedures, most frequently, paging. However, many subjects also used the scroll procedure.

Kolers, Duchnicky, and Ferguson (1981) compared the efficiency of reading texts presented on a video display terminal (VDT) in paged or scrolled formats. Performance was assessed in terms of efficiency of eye movements and reading rates. They found that scrolled texts were sometimes read more efficiently than paged text, and sometimes less so, depending on the scrolling rate employed. Thus, the research indicated that paging produced better performance than a line-by-line scrolling. However since little empirical research was available concerning line-by-line scrolling and no research was found dealing with the half-screen or full-screen continuous scroll concepts as described earlier, all three kinds of scrolling modes were included in the present study. Also, the scrolling rate was optimized on the basis of pilot work since scrolling rate has been shown to affect scrolling efficiency (Kolers et al., 1981; Alvarez, Murray, and Hakkinen, 1984).

Two other conditions affecting menuing and scrolling performance are the effects of window size and item familiarity. Window size refers to the number of lines

displayed to the user. Two studies by Darnell and Neal (1983, 1984) on text-editing performance with partial and full page displays used window sizes of 20 and 60 lines and 1 and 20 lines, respectively. The results showed no practical productivity difference between the displays for typical editing revisions after a moderate amount of practice. Two other research teams (Duchnicky and Kolers, 1983; Elkerton et al., 1982) did, however, report performance differences attributed to window size. Duchnicky and Kolers (1983) conducted a study on the readability of text scrolled on visual display terminals and found that there were no differences in reading rates between 1 and 2 lines and no differences between 4 and 20 lines, but that the first pair was significantly different from the second pair. Elkerton et al. (1982) evaluated strategies of interactive file search. They found that window size clearly affected total search time and the number of operations required to locate the target. The results revealed a distinct difference between a 1-line window and the 7-, 13-, and 19-line window sizes. No significant performance differences were found between the 7-, 13-, and 19-line window sizes. The present study examined a half-screen display of 12 lines and a full-screen display of 24 lines.

Familiarity with the information being sought may also affect menuing and scrolling performance. Smith (1967) examined the effects of familiarity on stimulus recognition and categorization. He reported that familiarity facilitated response times on both the recognition and categorization tasks. Preliminary empirical findings (Somberg, Boggs, and Picardi, 1982; Somberg and Picardi, 1983) regarding a search of computer menus indicated that familiarity with the goal information had an effect on the speed with which the correct item was selected from the menu. The present author was interested in examining whether familiarity improved performance using some access methods more than others.

This investigation contains a test of the hypothesis that the access strategy (menuing or scrolling) used to search through a body of information affects the speed and accuracy of task performance. Other hypotheses are that familiarity with goal words and size of display window affect operator speed and accuracy.

Method

Subjects

Of the forty-eight subjects used in the experiment, 24 were male and 24 were female. All had 20/20 corrected visual acuity and received extra credit in introductory psychology classes at the University of South Dakota for participating in the experiment. These subjects also read and signed a consent form. (See Appendix A.)

Materials and Apparatus

Stimuli. Twenty pilot subjects rated the familiarity-unfamiliarity of the stimulus items with a scale developed by the author. Four rating forms were used to develop appropriate descriptive categories. A preliminary and final copy of the rating form are presented in Appendix B. About 200 possible goal words were rated. The ratings of the goal words used in the experiment are displayed in Appendix C. If the word was correctly rated in the main category for 90% of the subjects and correctly rated in the intermediate, descriptive category for 50% of the subjects, then the

word was considered for use in the experimental structures.

Members of a single set of 64 words, 32 familiar and 32 unfamiliar, served as goal items (targets) in all conditions. These words were related by category names and descriptors. Figure 1 shows the 4-3 hierarchy used in this experiment. A portion of the scrolling structure is shown in Figure 2.

Another critical component of the experiment that required pilot work were the scrolling rates for the three scrolling structures. Each of twenty pilot subjects was asked to perform the task using one of the three scrolling structures. These pilot subjects were different from those in the word familiarity pilot study. Four scrolling rates were tested over five trials for each scrolling structure. The subjects provided performance data and informal subjective ratings of the various scrolling rates. In addition, the experimenter timed each scrolling structure ten times and computed the average time for each scrolling loop to cycle. The average times and the pilot subject performance data were both taken into consideration so that the scrolling loop cycles would be as comparable as possible. The scrolling rates used in the experiment were as follows: Line-by-line, 125 msec; half-screen, 2250 msec; full-screen, 2250 msec.

BIRD	Bird of Prey	Eagle	Merlin
		Hawk	Osprey
	Songbird	Bunting	Meadowlark
		Junco	Robin
	Tropical	Honeycreeper	Quetzel
		Parrot	Toucan
	Water Fowl	Duck	Merganser
		Goose	Scaup
FISH	Diadromous	Alewife	Shad
		American Eel	Sturgeon
	Fresh Water	Bass	Catfish
		Bowfin	Mudwinnow
	Open Ocean	Barracuda	Shark
		Manta	Skate
	Reef Inhabitant	Angelfish	Parrotfish
		Cardinalfish	Scorpionfish
INSECT	Carnivorous	Cicada Killer	Lacewing
		Flea	Mosquito
	Herbivorous	Chinch Bug	Locust
		Grasshopper	Walking Stick
	Omnivorous	Ant	House Fly
		Earwig	Stink Bug
	Scavenger	Carrion Beetle	Maggot
		Cockroach	Scorpion Fly
MAMMAL	Hoofed	Chamois	Gnus
		Deer	Sheep
	Pouched	Kangaroo	Phalanger
		Koala	Wallaby
	Primate	Ape	Lemur
		Aye-Aye	Monkey
	Rodent	Cavy	Squirrel
		Mouse	Vole

Figure 1: Experimental menu hierarchy.

BIRD	Bird of Prey	Eagle	Goal Word (in red)
		Hawk	
		Merlin	
		Osprey	
	Songbird	Bunting	
		Junco	
		Meadowlark	
		Robin	
	Tropical	Honeycreeper	
		Parrot	PAUSE
		Quetzel	
		Toucan	
	Water Fowl	Duck	
		Goose	FORWARD
		Merganser	
		Scaup	
FISH	Diadromous	Alewife	
		American Eel	BACKWARD
		Shad	
		Sturgeon	
	Fresh Water	Bass	
		Bowfin	SELECT ITEM
		Catfish	
		Mudwinnow	

Figure 2: Experimental scrolling structure (partial).

Apparatus. Visual acuity was tested with an American Optical Company Sight Scanner Model 1810A. A monitor and touch-sensitive digitizer tablet were used in conjunction with a microcomputer to present the experimental tasks. The tablet used was the Model E233 H/GT digitizing tablet manufactured by Elographics, Inc. Approximately four ounces of pressure were needed on the 27.94 cm X 27.94 cm active surface area for operation. Since the tablet was very sensitive and could be actuated by any pointing device, a commercially available X-ACTO burnisher with a 1.59 mm ball end used as a pointing stylus. Also, previous research demonstrated that the use of a stylus resulted in better performance than an unaided finger (Ellingstad, Parng, Gehlen, Swierenga, and Auflick, 1985). For the menuing condition, an off-tablet enter key was located on the left to confirm the subject's choice. This insertion mode was associated with rapid response times in the investigation by Ellingstad et al., 1985.

A template made of Lexan was placed over the tablet to delineate the touch-sensitive areas on the touch tablet corresponding to the buttons displayed on the screen. In addition, tablet overlays consisting of double-laminated sheets of paper were used to label the touch-sensitive areas on the tablet for the different

experimental conditions. Gehlen (1986) found that subjects provided with tablet labeling performed a visual cuing task more rapidly and with fewer errors than a no labeling group.

A general purpose controller, Model E271-60 from Elographics, Inc. was the interface between the tablet and microcomputer. The monochromatic displays used for the tasks were shown on an Amdec Color II Plus monitor (28 cm x 21 cm).

The computer system consisted of an IBM 5150 PC and an Okidata 83A dot matrix printer. The software for the tasks was written in Turbo Pascal (Borland International).

Design

A mixed-subjects design was employed to evaluate the effects of access method on a search task. Access method was a between-subjects independent variable. Four experimental conditions required subjects to search for targets by interacting with either a hierarchical menu structure or one of three scroll function structures, each having 64 goal items at the lower-most level. The hierarchical menu structure had four items on each of three levels of menus (a 4-3 tree structure). The three scrolling conditions were line-by-line, half-screen, or full-screen continuous

scrolling. The other between-subjects variable was window size. Two window sizes were used: 12 lines (half of a computer screen) and 24 lines (a full screen).

The within-subjects independent variable was level of word familiarity. The goal words were either classified as familiar or unfamiliar based on the pilot research. Thirty-two familiar goal words and 32 unfamiliar goal words were used in the experimental hierarchy.

Procedure: Menuing Condition

Subjects were seated in front of the CRT display and were asked to read the instructions. (See Appendix D.) A practice hierarchy, different from the experimental one, was used to instruct the subjects on the goal acquisition task. After completing five trials using the practice hierarchy, subjects were presented with the experimental hierarchy. Subjects were asked to perform the task as quickly and as accurately as possible.

Each goal acquisition trial began with the presentation of the goal word in red in the upper right corner of the screen. Appendicies E and F show the display layouts for the 12 and 24 line conditions. The goal word was displayed throughout the trial. The

order of the presentation was determined by the random selection of each goal word without replacement from the set of 64 goal words. After 2.0 seconds of presentation, four touch sensitive areas that looked like buttons appeared in the left portion of the display. The words corresponding to the menu category at the appropriate level appeared in the buttons and the display remained until the subject chose a category by touching the tablet (or until the computer timed out after 60 seconds). Following the subject's response, the next menu called by the subject appeared. Touch sensitive buttons ("PREVIOUS MENU" and "MAIN MENU") for backing up one level (intermediate menu) or two levels (main category menu) were also available to the subject. The menu selection process continued until the goal word was selected from the lowest level menu. On correct trials the word "CORRECT" appeared along with the subject's acquisition time rounded to the nearest 0.1 second. On incorrect trials the word "ERROR" was displayed. Either feedback message appeared 0.5 seconds after the final response and was displayed for 2.0 seconds. A 2.0-second rest separated the trials. The subject was given a one minute break after each of four 16-trial blocks. Error trials were repeated once at the end of each block.

<u>Procedure</u>: <u>Scrolling Conditions</u>

Subjects were seated in front of the CRT display and asked to read the instructions (Appendix H). A practice list of information was used to instruct the subjects on the various scrolling methods used to perform the goal acquisition task. After five trials with the practice scrolling structure, subjects received the experimental scrolling structure. They were asked to acquire the goal word as quickly and as accurately as possible.

Each trial began with the presentation of the goal word in red in the upper right corner of the screens where it remained throughout the trial. Appendicies I and J show the display layouts for the 12 and 24 line conditions. The order of the presentation was determined by the random selection of each goal word without replacement from the set of 64 goal words. After 2.0 seconds of presentation, either 12 or 24 lines of words appeared in the left portion of the display. The information scrolled either line-by-line, by half-screen, or by full-screen at a specified rate until the subject pressed a "PAUSE" button on the right side of the tablet to stop the scroll. Cursor keys, ("FORWARD and "BACKWARD") also located in the right side of the tablet, were then used to position the goal word on the top line of the window. A line designator

(§) also was displayed next to the top line to assist the subjects. Another button, also in the right side of the tablet, entered the subject's choice ("SELECT ITEM"). The screen displayed either a "CORRECT" or "ERROR" feedback message 0.5 seconds after the final response for 2.0 seconds. A 2.0-second rest separated the trials. The subject was given a one minute break after each of the four 16-trial blocks. Error trials were repeated once at the end of each block.

Questionnaire

A short questionnaire concerning computer programming experience, scrolling or menuing experience, and biology experience (Appendicies G and K) was administrated after the data collection. Subject responses to the questionnaire were then coded according to the following key:

Biology Major	0 = No
	1 = Yes
Birds Category	1 = Average exposure
	2 = More than average exposure
Insects Category	1 = Average exposure
	2 = More than average exposure
Mammals Category	1 = Average exposure
	2 = More than average exposure

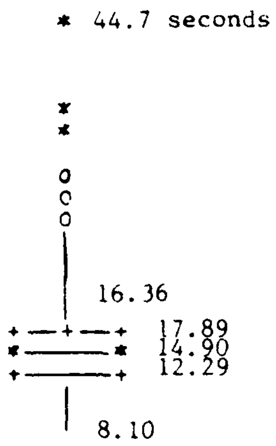
Computer Experience	Number of computer science classes taken	
Previous Experience	0 = No 1 = Yes	Previous experience with access method
Left Column Use (Scrolling)	0 = No 1 = Yes	Subjects were asked whether or not they scanned these columns in their search for the goal words.
Middle Column Use (Scrolling)	0 = No 1 = Yes	

Results

The total task time represented the sum of all individual response times plus the system response times for each trial. For both the menu and the scrolling structures the total task time included all responses related to backing up during the search. In the menuing condition some of the subjects searched the hierarchy for relatively long periods of time (over 100 seconds). Since it took only 75 seconds to press every button in the hierachy, scores over 100 seconds were considered outliers. To minimize the effect of these extraneous values, the data were winsorized (Dixon and Massey, 1969). Box and Whisker plots showing the dispersion of the data before and after it was winsorized are displayed in Figure 3.

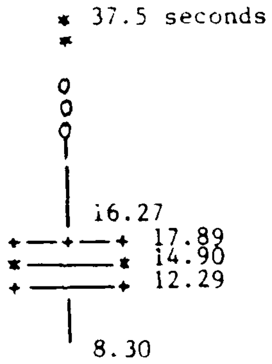
The overall task time means and standard deviations for the four access methods are shown in Table 1 as are the means and standard deviations for each access method, word familiarity level, and window size. Figure 4 graphically displays the means and confidence intervals for access method and word familiarity level. Figure 5 is the graphical representation of access method by word familiarity and window size.

Box Plot



Unwinsorized Data

Box Plot



Winsorized Data

The bottom and top edges of the box are located at the sample 25th and 75th percentiles.

The center horizontal line is drawn at the sample median and the central plus sign (+) is at the sample mean.

The central vertical lines (whiskers) extend from the box as far as the data extend, to a distance of at most 1.5 interquartile ranges. Any value more extreme than this is marked with a 0 if it is within 3 interquartile ranges of the box, or with an * if it is still more extreme.

Figure 3: Box and whisker plots of unwinsorized and winsorized data.

TABLE 1

MTIME Means and SDs for Dependent Variables

Word Familiarity

	Familiar Words			Unfamiliar Words			Across Word Fam and WS
	WS-12	WS-24	Across WS	WS-12	WS-24	Across WS	
	n=6	n=6	n=12	n=6	n=6	n=12	n=24
Menuing	11.72* 3.58	10.09 1.47	10.90 2.74	29.76 6.11	30.84 4.26	30.30 5.05	20.60 10.68
Line-by-Line Scrolling	12.24 1.71	11.17 2.08	11.70 1.90	12.85 2.47	12.24 2.89	12.54 2.58	12.12 2.26
Half-Screen Scrolling	18.04 1.34	15.82 2.10	16.93 2.04	19.41 2.89	16.83 1.52	18.12 2.58	17.52 2.36
Full-Screen Scrolling	15.10 2.39	14.38 2.56	14.73 2.39	15.00 2.01	14.92 1.67	14.96 1.57	14.85 1.99

* Note: The order in each cell is mean and standard deviation.

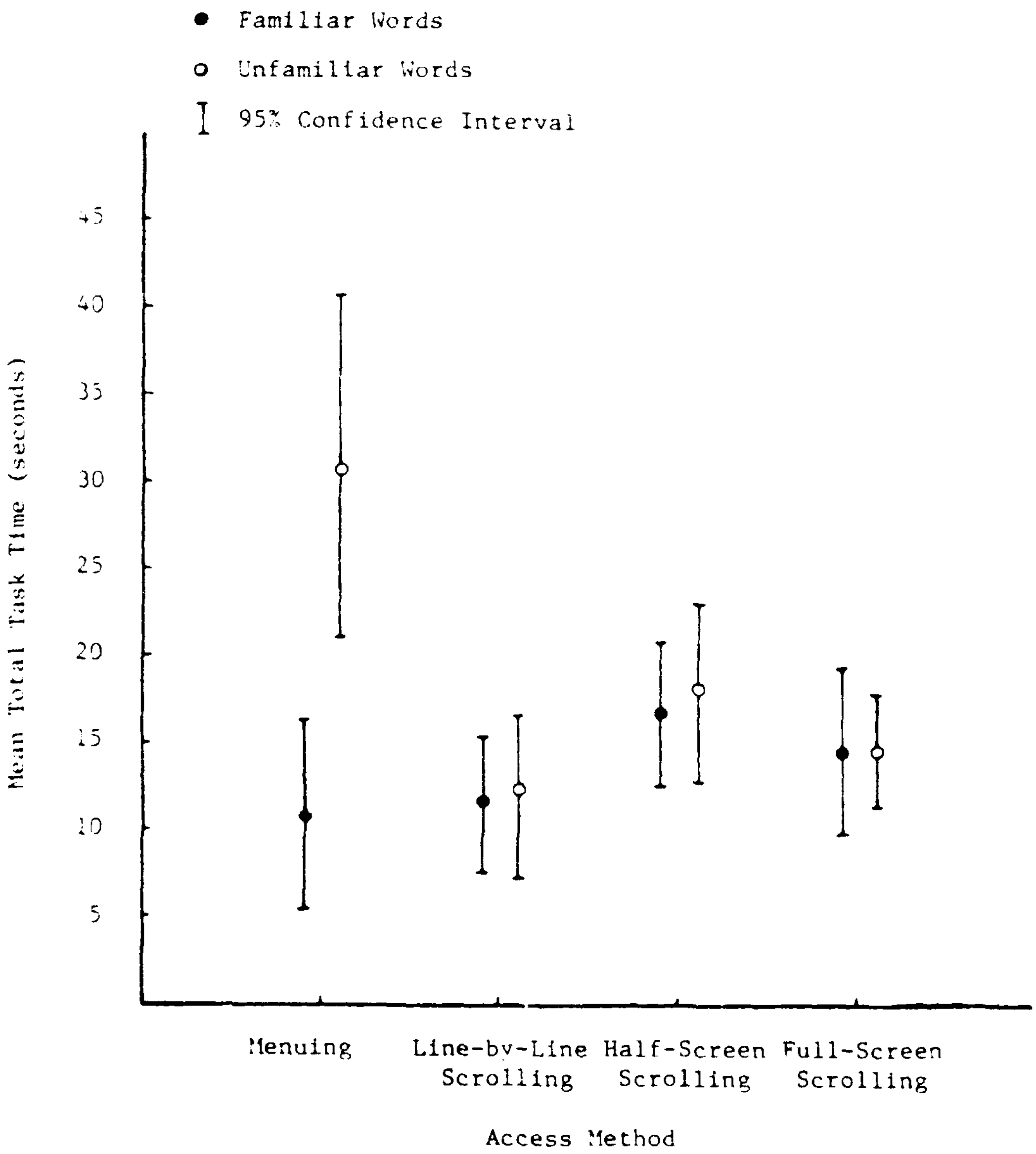


Figure 4: Means for access method by word familiarity.

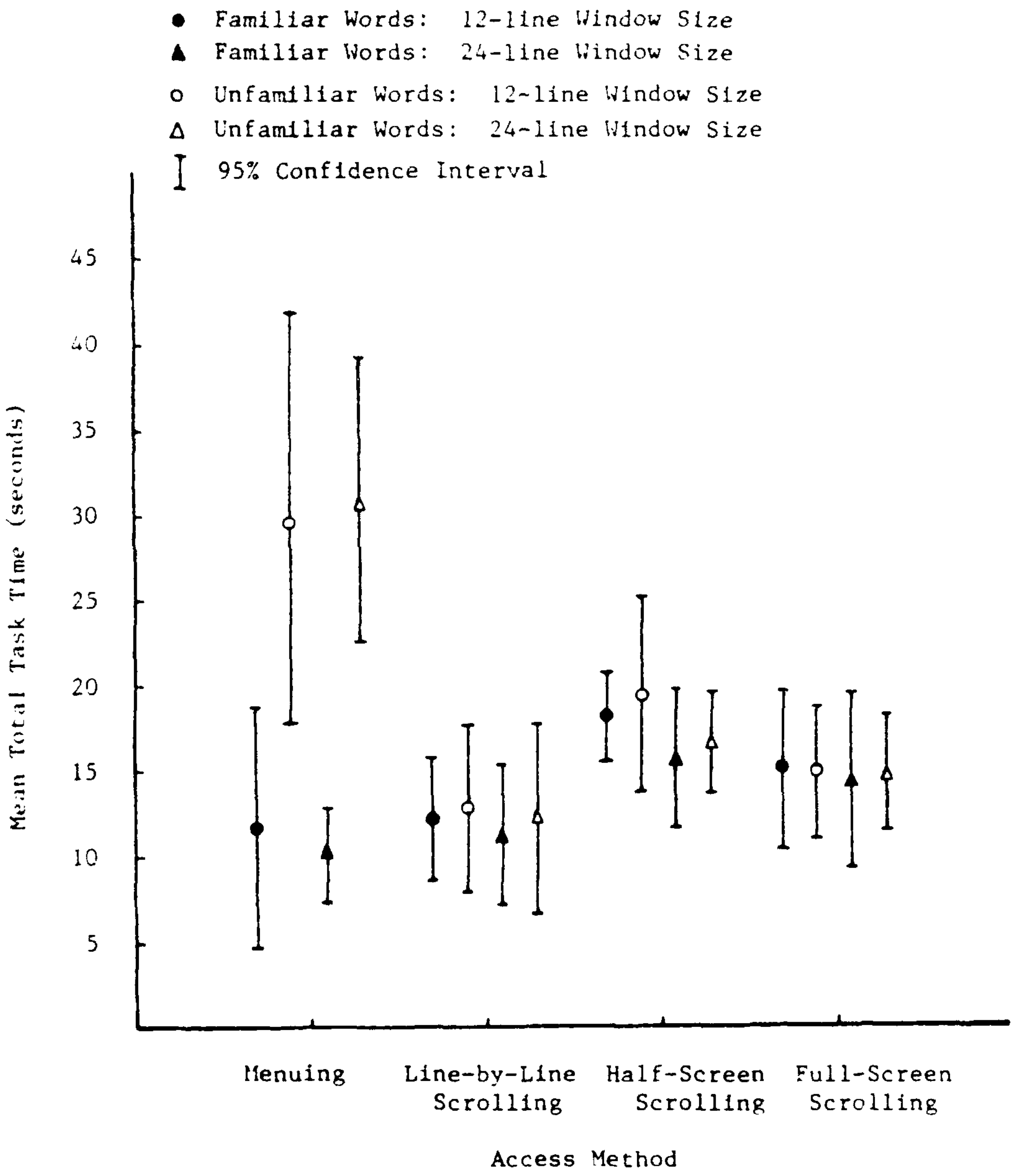


Figure 5: Means for access method by word fam. and window size.

A selection error measure was calculated for the menuing and scrolling tasks as the number of incorrect goal word choices, but because of a very low error rate no statistical analysis was attempted for this measure. Analysis of variance was conducted with the mean total task time (MTIME) as the dependent variable. Table 2 summarizes the results of this procedure.

Significant effects on time to goal acquisition were found for access method, word familiarity, and the access method by word familiarity interaction. Duncan's multiple range tests were conducted on access method and word familiarity to clarify the nature of the effects. As summarized in Table 3, the four access methods differed significantly from each other (alpha = 0.05). Examining the overall means, the line-by-line scrolling method was fastest, followed by full-screen, half-screen, and menuing. The Duncan's multiple range test for word familiarity showed the considerable difference in MTIME for the familiar versus unfamiliar words. Figure 4 graphically displays the access method by word familiarity interaction. Word familiarity dramatically affected MTIME in the menuing condition, but not as much in the three scrolling conditions, although the three scrolling conditions were significantly different from each other. The window size variable had no statistically significant effect, nor were there other interaction effects.

TABLE 2

ANOVA of MTIME data

Source	SS	df	MS	F	p § F
Between subjects					
Access Method	949.74	3	316.58	24.93	0.0001
Window Size	22.86	1	22.86	1.80	0.1873
Access Method X Window Size	17.17	3	5.72	0.45	0.7183
Subjects within groups	508.03	40	12.70		
Within subjects					
Word Familiarity	703.23	1	703.23	223.61	0.0001
Access Method X Word Familiarity	1567.56	3	522.52	166.15	0.0001
Window Size X Word Familiarity	4.46	1	4.46	1.42	0.2405
Access Method X Word Familiarity X Window Size	7.65	3	2.55	0.81	0.4951
Word Familiarity by Subjects within groups	125.80	40	3.14		

TABLE 3

Duncan's Multiple Range Tests for MTIME

Dependent Variable	Mean	Duncan Group
Access Method		
Menuing	20.60	A
Half-Screen Scrolling	17.52	B
Full-Screen Scrolling	14.85	C
Line-by-Line Scrolling	12.12	D

To examine further the influence of word familiarity, separate analyses of variance were conducted for familiar and for unfamiliar words sets (Table 4). The ANOVA for the familiar words resulted in significant access method and window size effects. The ANOVA for the unfamiliar words revealed a significant access method effect, but no window size effect. The Duncan's multiple range test for the familiar goal words revealed that the various access methods remained significantly different as in the overall analysis of variance, but that the menuing access method was the fastest condition rather than the slowest. The rest of the order did not change. For the unfamiliar goal words the Duncan's multiple range test for access methods showed the same order as in the overall analysis of variance. Table 5 displays the results of the Duncan's multiple range tests.

Although window size was not significant in the overall analysis, it was significant for the familiar words in the separate analysis. The Duncan's multiple range test showed subject response to be faster with the 24 than with the 12-line window (Table 5). The window size variable was not significant for the unfamiliar words. Figure 5 graphically displays MTIME by access method and window size for the familiar and unfamiliar goal words.

TABLE 4

ANOVAs on MTIME for Each Word Familiarity Level

Source	SS	df	MS	F	p § F
Familiar Goal Words					
Access Method	279.05	3	93.02	18.27	0.0001
Window Size	23.77	1	23.77	4.67	0.0368
Access Method X Window Size	8.87	3	2.96	0.25	0.8586
Subject within group	203.67	40	5.09		
Unfamiliar Goal Words					
Access Method	2238.24	3	746.08	69.38	0.0001
Window Size	3.56	1	3.56	0.33	0.5682
Access Method X Window Size	20.95	3	6.98	0.65	0.5879
Subject within group	430.16	40	10.75		

TABLE 5

Duncan's for MTIME on Access Method

Dependent Variable	Mean	Duncan Group
Familiar Goal Words		
Half-Screen Scrolling	16.93	A
Full-Screen Scrolling	14.74	B
Line-by-Line Scrolling	11.70	C
Menuing	10.90	D

Dependent Variable	*Mean*	*Duncan Group*
Unfamiliar Goal Words		
Menuing	30.30	A
Half-Screen Scrolling	18.12	B
Full-Screen Scrolling	14.96	C
Line-by-Line Scrolling	12.54	D

Note: Means with different Duncan Group letters are significantly different at alpha = 0.05.

Supplemental Analysis

To understand better the subject performance in each of the four access method conditions, supplemental time measures were recorded as well as indicies reflecting the number of times the various buttons were pressed. For the menuing condition, the supplemental measures taken were:

1. M1PRS--Mean time from initial presentation of the goal word to the first button press
2. MPE1--Mean path error, one level: The number of times the subject backed up one level in the menu hierarchy
3. MPE2--Mean path error, two levels: The number of times the subjects backed up two levels.

The time lines in Figure 6 clarify the relationships between MTIME and the supplemental measures.

For the menuing condition, M1PRS, MPE1, and MPE2 were time segments of MTIME. Subject performance was broken down into the percentage of total task time taken to perform each aspect of the task. Subjects used an average of 2.71 seconds to examine the goal word in the corner of the display and select a main category. This average time (M1PRS) represents only 13% of MTIME. The remaining time was spent searching between the intermediate (descriptive) and the lowest (goal word) categories trying to find the target goal

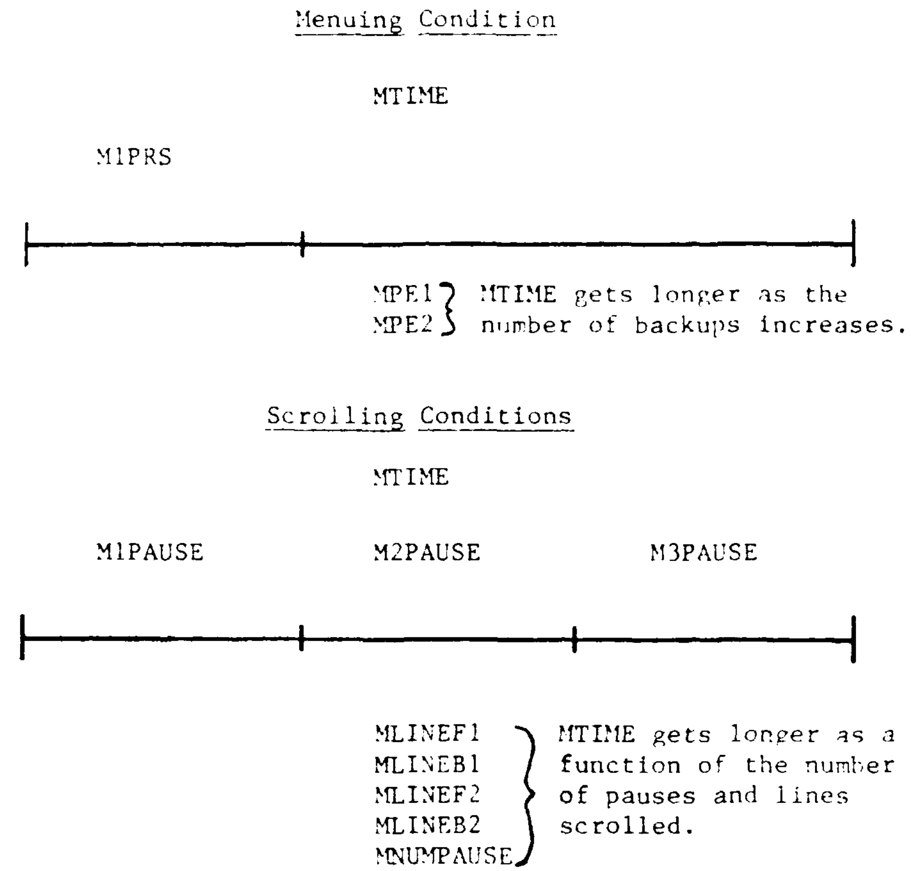


Figure 6: Time lines for supplemental measures.

word. Results of the regression analysis of MTIME on MPE1 and MPE2 revealed that the variables accounted for 62% of the total variance. MPE1 made a significant contribution to the regression while MPE2 did not. Table 9 shows the means and standard deviations of these measures and the regression analysis results.

For the three scrolling conditions, the supplemental measures collected were:

1. MNUMPAUSE--Mean number of times the PAUSE button was pressed throughout a trial
2. M1PAUSE--Mean time from initial presentation of the goal word to the first PAUSE button press
3. M2PAUSE--Mean time from first PAUSE button press to final PAUSE button press
4. M3PAUSE--Mean time from the final PAUSE button press to selection of the goal word
5. MLINEF1--Mean number of lines scrolled forward, after the PAUSE button was pressed the first time
6. MLINEB1--Mean number of lines scrolled backward, after PAUSE button was pressed the first time
7. MLINEF2--Mean number of lines scrolled forward, after the second time the PAUSE button was pressed
8. MLINEB2--Mean number of lines scrolled backward, after the second time the PAUSE button was pressed.

TABLE 9

Supplemental Menuing Means, SDs, and Regression Results

Variable	Mean	Standard Deviation
M1PRS	2.71	0.44
MPE1	1.84	0.50
MPE2	0.42	0.13

Source	SS	df	MS	F	p § F	R2
Regression Model	134.89	2	67.44	7.29	0.0131	0.62
Error	83.28	9	9.25			

Variable	df	Parameter Estimate	Standard Error	T for H: Parameter=0	p § F
MPE1	1	9.09	2.97	3.06	0.0136
MPE2	1	-10.73	11.06	-0.97	0.3576

For the line-by-line scrolling conditions the means and percentages of total solution time for the three segments of MTIME were 9.26 seconds and 76% for M1PAUSE; 0.35 seconds and 3% for M2PAUSE; and 2.51 seconds and 21% for M3PAUSE. The M1PAUSE variable accounted for most of MTIME. The regression analysis of MTIME on MLINEF1, MLINEB1, MLINEF2, MLINEB2, and MNUMPAUSE accounted for 91% of the total variance. MLINEF1 made a significant contribution to the regression, while MNUMPAUSE, MLINEB1, MLINEF2, and MLINEB2 did not. Table 10 displays the means and standard deviations for the supplemental measures and the regression results.

For the half-screen scrolling condition, the means and percentages of the MTIME time segments were 12.63 seconds and 72% for M1PAUSE; 0.68 seconds and 4% for M2PAUSE; and 4.22 seconds and 24% for M3PAUSE. The results of the regression analysis on MTIME for the supplemental error measures were not significant. The regression of the error measures accounted for 51% of the total variance. No variable contributed significantly to the regression. See Table 11 for the regression results.

The full-screen scrolling condition resulted in means and percentages for the segments of MTIME of 8.34 seconds and 56% for M1PAUSE; 1.11 seconds and 8% for

TABLE 10

Supplemental Line-by-Line Scrolling Results

Variable	Mean	Standard Deviation
MNUMPAUSE	1.05	0.04
M1PAUSE	9.26	0.80
M2PAUSE	0.35	0.38
M3PAUSE	2.51	1.52
MLINEF1	0.86	0.95
MLINEB1	0.59	0.46
MLINEF2	0.05	0.12
MLINEB2	0.12	0.15

Source	SS	df	MS	F	p § F	R2
Regression Model	47.13	5	9.43	11.48	0.0050	0.91
Error	4.93	6	0.82			

Variable	df	Parameter Estimate	Standard Error	T for H: Parameter=0	p § F
MNUMPAUSE	1	-1.63	14.49	-0.11	0.9141
MLINEF1	1	2.29	0.63	3.62	0.0111
MLINEB1	1	-0.09	1.04	-0.09	0.9353
MLINEF2	1	-3.52	4.23	-0.83	0.4375
MLINEB2	1	3.64	2.63	1.39	0.2144

TABLE 11

Half-Screen Supplemental Results

Variable	Mean	Standard Deviation
MNUMPAUSE	1.06	0.05
M1PAUSE	12.63	3.20
M2PAUSE	0.68	0.77
M3PAUSE	4.22	1.33
MLINEF1	3.05	1.35
MLINEB1	1.64	1.62
MLINEF2	0.23	0.40
MLINEB2	0.09	0.14

Source	SS	df	MS	F	p § F	R2
Regression Model	22.48	5	4.50	1.23	0.3984	0.51
Error	21.94	6	3.66			

Variable	df	Parameter Estimate	Standard Error	T for H: Parameter=0	p § F
MNUMPAUSE	1	-9.48	22.14	-0.43	0.6835
MLINEF1	1	-1.07	0.58	-1.86	0.1129
MLINEB1	1	0.11	0.71	0.15	0.8869
MLINEF2	1	1.80	3.84	0.47	0.6558
MLINEB2	1	-4.91	8.89	-0.55	0.6004

M2PAUSE; and 5.39 seconds and 36% for M3PAUSE. The regression analysis of MTIME on the error measures was not significant but accounted for 28% of the total variance. Table 12 displays the descriptive statistics and the results of the regression analysis for the supplemental variables.

TABLE 12

Full-Screen Scrolling Supplemental Results

Variable	Mean	Standard Deviation
MNUMPAUSE	1.11	0.08
M1PAUSE	8.34	1.94
M2PAUSE	1.11	0.76
M3PAUSE	5.39	1.83
MLINEF1	6.01	2.90
MLINEB1	1.11	0.82
MLINEF2	0.29	0.22
MLINEB2	0.48	0.51

Source	SS	df	MS	F	p § F	R2
Regression Model	9.14	5	1.83	0.48	0.7826	0.28
Error	22.97	6	3.83			

Variable	df	Parameter Estimate	Standard Error	T for H: Parameter=0	p § F
MNUMPAUSE	1	13.25	12.04	1.10	0.3133
MLINEF1	1	0.17	0.42	0.41	0.6945
MLINEB1	1	0.75	0.77	0.98	0.3671
MLINEF2	1	-0.83	5.25	-0.16	0.8799
MLINEB2	1	-1.24	2.09	-0.59	0.5763

Questionnaire Analysis

The short questionnaire regarding menuing and scrolling experience, number of computer science classes taken, and biology background relating to the four major categories was used to determine whether or not this information had an effect on MTIME. Table 13 displays the frequencies and percents of the questionnaire measures. Table 14 shows the means and standard deviations of the variables. The regression of MTIME on these variables was significant, accounting for 35% of the total variance. Subject knowledge of mammals and the number of computer science classes taken significantly contributed to the regression. Table 15 shows a summary of the regression analysis.

TABLE 13

Frequencies and Percents for Questionnaire Data

Variable	Frequency	Cum Freq	Percent	Cum Percent
Biology Major				
0	42	42	87.50	87.50
1	6	48	12.50	100.00
Birds				
1	43	43	89.58	89.58
2	5	48	10.42	100.00
Fish				
1	46	46	95.83	95.83
2	2	48	4.17	100.00
Insects				
1	48	48	100.00	100.00
Mammals				
1	45	45	93.75	93.75
2	3	48	6.25	100.00
Previous Experience				
0	39	39	81.25	81.25
1	9	48	18.75	100.00
Computer Experience				
0	11	11	22.92	22.92
1	22	33	45.83	68.75
2	14	47	29.17	97.92
3	1	48	2.08	100.00
Left Column				
NA	12	.	.	.
0	13	13	36.11	36.11
1	23	36	63.89	100.00
Middle Column				
NA	12	.	.	.
0	28	28	77.78	77.78
1	8	36	22.22	100.00

TABLE 14

Means and SDs Results for Questionnaire Data

Variable	Mean	Standard Deviation
Biology Major	0.13	0.33
Birds	1.10	0.31
Fish	1.04	0.20
Insects	1.00	0.00
Mammals	1.06	0.24
Previous Experience	0.19	0.39
Computer Experience	1.10	0.78
Left Column	0.64	0.49
Middle Column	0.22	0.42

TABLE 15

Regression Results for the Questionnaire Data

Source	SS	df	MS	F	p § F	R2
Regression Model	297.06	6	49.51	3.62	0.0056	0.35
Error	560.09	41	13.66			

Variable	df	Parameter Estimate	Standard Error	T for H: Parameter=0	p § F
Biology Major	1	0.009	2.00	0.004	0.9966
Birds	1	-1.28	2.27	-0.56	0.5769
Fish	1	-1.42	3.89	-0.37	0.7167
Mammals	1	7.14	2.85	2.51	0.0162
Computer Experience	1	-2.04	0.74	-2.76	0.0085
Previous Experience	1	-1.61	1.47	-1.10	0.2795

Discussion

This experiment was to investigate menuing and scrolling as alternative information management techniques. A 4-3 menu structure and three types of scrolling were used: line-by-line, half-screen, and full-screen. The effects of word familiarity and display window size were also examined. It was hypothesized that these variables would affect the speed and accuracy of task performance.

Very few errors were recorded under any access method. Although the instructions requested that subjects perform as quickly and as accurately as possible, they seemed to concentrate on errorless performance in spite of the extra time that might have taken. Also, the goal word in the upper right corner of the screen was present throughout the trial, and subjects could compare it with selections presented on the display. Thus, the rare errors were probably due to inadvertant button presses.

The mean total task time (MTIME) data were winsorized to minimize the effect of extreme values. Some of the MTIME scores were over 100 seconds, a duration more than sufficient to search the complete

hierarchy used in the study. Therefore, to minimize the effect of these large values, the data were winsorized such that the smallest and largest observations were given the value of their nearest neighbor. According to Dixon and Massey (1969), the mean computed on the modified sample would not have lost much efficiency if the extremes were actually valid. If the extremes were not valid, then the estimate was improved.

Analysis of variance for the MTIME dependent variable revealed significant access method, word familiarity, and access method by word familiarity interaction effects. Window size (across word familiarity) was not significant, nor were any of the other interactions. The window size results seem to confirm the findings of Darnell and Neal (1983, 1984), Duchnicky and Kolers (1983), and Elkerton et al. (1982). These previous investigators varied the window size from 1 to 60 lines and generally found that window sizes larger than four lines were not significantly different from each other. The 12- and 24-line window sizes used in the present experiment were in the range used in the other studies and yielded similiar results across the word familiarity levels.

Line-by-line scrolling was the fastest access method, followed by full-screen, half-screen, and

menuing. These findings contradict earlier research (Schwarz et al., 1983; Kolers et al., 1981) which found paging (equivalent to full-screen scrolling) to be superior to line-by-line scrolling. Closer inspection of this previous research revealed that the scrolling rate of the paging and scrolling structures was either under the subject's control or was an experimental variable. The fixed scrolling rates for the three scrolling structures in the present study seemed to result in performance and preference differences.

The overall means of this experiment indicated that finding a goal word was easiest when the subject simply had to watch the list scroll and pause the scroll loop when the goal word was near or at the top line of the display window. Also, once the word appeared at the bottom of the window, the subject could watch it move up to the top line, allowing the system to do most of the "work".

The supplemental data collected offered additional insight into subject performance using the line-by-line scrolling method. Generally, subjects paused the scrolling loop only when the goal word was visible in the display window, indicating that the subjects were reading the list as the goal words scrolled by. The subjects did not pause the scrolling loop, then, to check for the goal word, rather they waited until the

goal word appeared in the display window. The nonsignificance of MNUMPAUSE, MLINEF2, and MLINEB2 in the regression analysis seemed to confirm this strategy of subject performance. The M1PAUSE variable indicated that 76%, or an average of 9.26 seconds, was spent scanning for the goal word. All of the other aspects of the task used the remaining time.

MLINEF1 made a significant contribution to the regression while MLINEB1 did not. Subjects were hesitant in all of the scrolling conditions to let the goal word scroll out of the window, even one or two lines beyond, which meant that they paused the scrolling loop prematurely most of the time. The subjects appeared to pause the scrolling loop a few lines before the goal word was on the top line of the display window, rather than allowing the goal word to scroll to the top line or a few lines beyond the upper limit of the display window which would have been the most efficient strategy.

Full-screen scrolling, the next fastest condition, required subjects to concentrate on scanning the list of information as it "paged" screen-by-screen. Subjects spent an average of 8.34 seconds for M1PAUSE (56% of MTIME) which was similar to the line-by-line scrolling method. Subjects took about 5.39 seconds (36% of MTIME) for M3PAUSE and only about 1 second (8%)

for M2PAUSE. The supplemental measures did not result in a significant regression, and they accounted for only 28% of the total variance.

Observing the subjects as they performed the task revealed two strategies for obtaining the goal word. Most subjects paused the scrolling loop as soon as they saw the word anywhere in the display window. Once the scrolling loop was paused, if the word was located near the bottom of the display window, some subjects unpaused the main scrolling loop and let the goal word scroll beyond the display window. Then they simply backed up the loop (BACKWARD button) until the goal word appeared on the top line of the display window. Other subjects did not unpause the main scrolling loop, but used the FORWARD button to advance the loop until the goal word was positioned on the top line of the display window. The former strategy seemed to be more efficient as it took less time.

Half-screen scrolling was the most difficult of the three scrolling methods to conceptualize as well as use, even though the subjects saw the goal word twice. The goal word appeared once in the bottom half of the display and then again when the information moved from the bottom half to the top portion of the display. Longer total task times resulted because subjects tended not to see the goal word in the list the first

time through the scrolling loop. Also, the list of words appeared to "jump" on the screen. The average time for M1PAUSE was 12.63 seconds, representing 72% of MTIME. The regression was not significant, but accounted for 51% of the total variance.

As in the full-screen scrolling condition, two strategies seemed to be utilized by the subjects to position the goal word on the top line. Some subjects paused the main scrolling loop as soon as the goal word appeared in the bottom half of the screen. Then they used the FORWARD and BACKWARD buttons to position the goal word on the top line. This took more time than allowing the main scroll loop to move the word to the top half of the screen and then pausing the main scrolling loop and using the FORWARD and BACKWARD buttons to position the goal word on the top line. Subjects used the FORWARD button most of the time, using the BACKWARD button mostly when they overshot the top line while using the FORWARD button.

Overall, menuing was the slowest condition. If the subject knew the goal word, then using the menu structure to locate the goal word at the lowest level was straightforward. However, when the goal word was unfamiliar, the subject had to develop a strategy for searching for the goal word. The subjects typically had to search about half of the menu structure to

locate the goal word. The supplemental data collected provided more insight into subject performance on this task. Subjects used a relatively short time, about 2.71 seconds, (13% of MTIME) to examine the goal word and select a main level category. The subjects spent the rest of their time searching between the intermediate (descriptive) and the lowest (goal word) categories trying to find the target goal word. The regression analysis of MTIME on MPE1 and MPE2 accounted for 62% of the total variance and confirmed that MPE1 significantly contributed to the regression while MPE2 did not. The results indicated that subjects went from the goal word level back to the intermediate level and tried all of the intermediate level pathways rather than going from the goal word level directly back to the main category level.

The familiarity level of the goal word significantly affected subject performance. As might be expected, searching for unfamiliar goal words took longer than finding familiar words for the four access methods. All access methods were significantly different for both levels of familiarity. Of the three scrolling conditions, familiarity with the goal words helped the most in the half-screen scrolling condition, which seemed to be more difficult than the other two scrolling conditions. The effect for the menuing

condition, however, was the most pronounced. It appears from examining Table 5 and Figure 5 that the significant interaction effect was due to the difference in the menuing condition means. To obtain the goal word using the menu structure, the subject had to choose the appropriate categories to obtain the goal word, whereas the scrolling conditions only required recognition of the goal word in the list. Analyses of variance conducted separately for the two levels of word familiarity revealed the more specific nature of the effect of goal word familiarity. The menuing condition, which had been the slowest overall condition, became the fastest condition when the goal words were familiar, with subjects proceeding through the menu hierarchy relatively quickly. The system response time was also minimal. Using the scrolling access methods, however, the subject had to wait for the system to loop through the goal word list, producing longer system response times.

Performance using the two display window sizes was also affected by the familiarity of the goal word. When the goal word was familiar, performance using the 24-line window was significantly faster than performance using the 12-line window for all access methods. Having more information displayed on the screen for the scrolling conditions helped the subjects

detect the goal words more quickly. Under menuing, the faster response times were most likely due to the greater separation between the button areas. When the buttons were close together, positioning the stylus correctly on the touch tablet was somewhat more time-consuming. The nonsignificant results of the unfamiliar goal words for window size indicated that having more information on the screen did not seem to facilitate the search, but did not hinder the search for the goal word, either.

Although analysis of the questionnaire data produced a significant regression on MTIME, only 35% of the total variance was accounted for by the nine variables. Only two of the self-reported variables, knowledge of mammals and number of computer science classes taken, were statistically significant predictors.

Summary and Recommendations

The biological database developed for this research effort provided a good experimental paradigm for the study of menuing and scrolling as alternative information management techniques. Using this paradigm, line-by-line, half-screen, full-screen scrolling, and menuing were found to be significantly different from each other. The fastest condition depended on the familiarity level of the goal word, but not on window size. When the goal word was familiar, menuing was fastest, followed by line-by-line, full-screen, and half-screen scrolling. For unfamiliar goal words, line-by-line scrolling was fastest, followed by full-screen scrolling, half-screen scrolling, and menuing.

These results suggest that the operator's familiarity with the information in the database being searched is important. This study used subjects who were naive with respect to the assigned access method. A similar study of experienced subjects might provide valuable additional information.

Other recommendations for improving menuing and/or scrolling as access methods are user aids such as:

1. displaying the sequence of frames which led to the current one,
2. allowing the scrolling rate to be under subject control, and
3. combining the various access methods.

In the present investigation the basic structure of the 4-3 menu hierarchy was described to the subject, but no visible log of the pathways pursued by the subject was displayed during the experiment. Thus, the subjects were unsure about how they arrived at the particular menu that was currently displayed. After some practice subjects began to understand the nature of the hierarchy. Having a visible history of the sequence that led to the menu the subject was examining might be an effective user aid. More examination in this area may be required, especially with systems that are more complex, having more options at each level and greater penalties for incorrect choices.

The scrolling rates used in the three scrolling conditions were determined from pilot research. Other studies have employed subject controlled scrolling rates. Variable scrolling rates may improve the efficiency of scrolling as an access method. As the subjects became more familiar with the structure of the information in the scrolling loop, system response became a constraint. When the subjects thought the

goal word was in the middle or toward the end of the list of words in the loop, they had to wait for the system to scroll to that point. If there was a way for the subjects to make the loop scroll faster, they would have utilized it and total task times would have been considerably shorter in these cases, although there may also have been more error. Further research may be necessary to examine performance with fixed and variable scrolling rates.

Finally, combinations or hybrids of the access methods may be useful. As the list of information in the scrolling loop gets longer or the number of options increase in the menuing structure, a hybrid structure might be the optimal solution. For example, major categories or functional groups could be arranged into a menu structure. When a particular option was selected from this main menu, then the list of choices could scroll through a display window until a selection was made. On-line store inventories, on-line product location displays (aisle and shelf information), on-line help manuals, and other database management systems would probably need to employ such a hybrid structure. More extensive examination in this area, as well as the others mentioned above, is essential to design and develop efficient user-centered systems.

References

Allen, R. B. (1982). Cognitive factors in human interaction with computers. In A. Badre and B. Shneiderman (Eds.), Directions in human/computer interaction (pp. 1-26). Norwood, NJ: Ablex.

Allen, R. B. (1983, February). Cognitive factors in the use of menus and trees: An experiment. IEEE Journal on Selected Areas in Communication, SAC-1 (2), 333-336.

Alvarez, M. J., Murray, J. T., and Hakkinen, M. T. (1984). Search performance as a function of depth in processing and scrolling rate. (Abstract). Proceedings, 28th Annual Meeting, Human Factors Society, 709.

Baker, C. A. (1982, November). Human-computer interaction. Computer, 15, 9-11.

Bo, K. (1982, November). Human-computer interaction. Computer, 15, 9-11.

Brosey, M. and Shneiderman, B. (1978). Two experimental comparisons of relational and hierarchical database models. International Journal of Man-Machine Studies, 10, 625-637.

Bury, K. F., Boyle, J. M., Evey, R. J., and Neal, A. S. (1982, March 15-17). Windowing vs scrolling on a visual display terminal. Proceedings Human Factors in Computer Systems, Gaithersburg, MD, 41-44.

Bury, K. F., Boyle, J. M., Evey, R. J., and Neal, A. S. (1980, November). Data manipulation on a visual display terminal: Windowing or scrolling? (Tech. Rep. No. HFC-36). San Jose, CA: International Business Machines Corporation, Human Factors Center, General Products Division.

Card, S. K., Moran, T. P., and Newell, A. (1980). Computer text-editing: An information-processing analysis of a routine cognitive skill. Cognitive Psychology, 12, 32-74.

Darnell, M. J. and Neal, A. S. (1984). Effect of the amount and format of displayed text on text editing performance. In E. Grandjean (ed.), Ergonomics and health in modern offices. London: Taylor & Francis, 220-226.

Darnell, M.J. and Neal, A. S. (1983). Text editing performance with partial and full page displays. Proceedings, 27th Annual Meeting, Human Factors Society, 821-825.

Dixon, W. J. and Massey, Jr., F. J. (1969). Introduction to Statistical Analysis. (3rd ed.). New York: McGraw-Hill.

Duchnicky, R. L. and Kolers, P. A. (1983). Readability of text scrolled on visual display terminals as a function of window size. Human Factors, 25 (6), 683-692.

Dumais, S. T. and Landauer, T. K. (1984). Describing categories of objects for menu retrieval systems. Behavior Research Methods, Instruments & Computers, 16 (2), 242-248.

Durding, B. M., Becker, C. A., and Gould, J. D. (1977). Data organization. Human Factors, 19 (1), 1-14.

Drury, C. G. and Clement, M. R. (1978). The effect of area, density, and number of background characters on visual search. Human Factors, 20 (5), 592-602.

Elkerton, J., Williges, R. C., Pittman, J. A., and Roach, J. (1982). Strategies of interactive file search. Proceedings, 26th Annual Meeting, Human Factors Society, 83-86.

Ellingstad, V. S., Parng, A. K., Gehlen, J. R., Swierenga, S. J., and Auflick, J. (1985, March). An evaluation of the touch tablet as a command and control input device. Final Report: Subcontract N66001-83-D-0054 with Westec Services and Naval Ocean Systems Center. Vermillion: University of South Dakota, Human Factors Laboratory.

Friedell, M., Kramlich, D., Herot, C. F., and Carling, R. (1979, August). Spatial Data Management System. (MDA 903-78-C-0122). Cambridge, MA: Defence Advanced Research Projects Agency. (DTIC No. AD A083948)

Gehlen, J. R. (1986, January). Function selection with the tablet: The effect of labels for visual cuing. Tech. Rep., Contract N66001-85-C-0253, Naval Ocean Systems Center. Vermillion, SD: The University of South Dakota, Human Factors Laboratory.

Grimes, J. D. (1979, January). A knowledge oriented view of user interfaces. Proceedings of the Hawaii International Conference of System Science, Honolulu, 158-163.

Happ, A. J. and Lewis, J. R. (1983). The effect of screen boundary, familiarity, and data type on user's decision to scroll or window. Proceedings, 27th Annual Meeting, Human Factors Society, 512-515.

Hauptmann, A. G. and Green, B. F. (1983). A comparison of command, menu-selection and natural-language computer programs. Behaviour and Information Technology, 2 (2), 163-178.

Herot, C. F., Kramlich, D., Carling, R., Friedell, M., and Farrell, J. (1978, November). Spatial Data Management System. (MDA 903-78-0122). Cambridge, MA. (DTIC No. AD A068863)

Johnson, D. H. and Hartson, H. R. (1982, May). The role of tools as a dialogue author in creating human-computer interfaces (CSIE-82-8). Blacksburg, VA: Virginia Polytechnic Institute & State University, Computer Science. (DTIC No. AD A118146)

Kiger, J .I. (1984). The depth/breadth trade-off in the design of menu-driven user interfaces. International Journal of Man-Machine Studies, 20 201-213.

Kolers, P. A., Duchnicky, R. L., and Ferguson, D. C. (1981). Eye movement measurement of readibility of CRT displays. Human Factors, 23, 517-527.

Lee, E. and MacGregor, J. (1985). Minimizing user search time in menu retrieval systems. Human Factors, 27 (2), 157-162.

Miller, D. P. (1981). The depth/breadth tradeoff in hierarchical computer menus. Proceedings, 25th Annual Meeting, Human Factors Society, 296-300.

Miller G. A. (1956, March). The magical number seven, plus or minus two: Some limits on our capacity for processing information. The Psychological Review, 63 (2), 81-97.

Monk, T. H. and Brown, B. (1975). The effect of target surround density on visual search performance. Human Factors, 17 (4), 356-360.

Moran, T. P. (1981, March). An applied psychology of the user. Computing Surveys, 13 (1), 1-11.

Neisser, U. and Beller, H. K. (1965). Searching through word lists. British Journal of Psychology, 56 (4), 349-358.

Ramsey, H. R. and Atwood, M. E. (1979, September 21). Human factors in computer systems: A review of the literature (Tech. Rep. SAI-79-111-DEN). Englewood, CO: Science Applications. (DD No. AD A075679)

Savage, R. E., Habinek, J. K., and Barnhart, T. W. (1982, March 15-17). The design, simulation, and evaluation of a menu driven user interface. Proceedings Human Factors in Computer Systems, Gaithersburg, MD, 36-40.

Schulman, A. I. (1971). Reconition memory for targets from a scanned word list. British Journal of Psychology, 62 (3), 335-346.

Schwarz, E., Beldie, I. P., and Pastoor, S. (1983). A comparison of paging and scrolling for changing screen contents by inexperienced users. Human Factors, 25 (3), 279-282.

Shackel, B. (1980). Dialogues and language--can computer ergonomics help? Ergonomics, 23 (9), 857-880.

Shneiderman, B. (1980). Software psychology: Human factors in computer and information systems. Cambridge, MA: Winthrop.

Smith, E. E. (1967). Effects of familiarity on stimulus recognition and categorization. Journal of Experimental Psychology, 74 (3), 324-332.

Snowberry, K., Parkinson, S. R., and Sisson, N. (1983). Computer display menus. Ergonomics, 26 (7), 699-712.

Somberg, B. L., Boggs, G. J., and Picardi, M. C. (1982, October). Search and decisions processes in human interaction with menu-driven systems. Presented at the Human Factors Society 26th Annual Meeting, Seattle, WA.

Somberg, B. L. and Picardi, M. C. (1983). Locus of the information familiarity effect in the search of computer menus. Proceedings, 27th Annual Meeting, Human Factors Society, 826-830.

Tombaugh, J. W. and McEwen, S. A. (1982, March 15-17). Comparison of two information retrieval methods on Videotex: Tree-structure versus alphabetical directory. Proceedings Human Factors in Computer Systems, Gaithersburg, MD, 106-110.

Appendix A

Consent Form for Participation

You are invited to participate in an information management techniques study conducted at the Human Factors Laboratory in the Psychology Department. Your participation in this study is voluntary, but you must be of legal age (18 years or older), and be legally competent to give this consent.

If you agree to participate, you will be seated in front of a monitor and a touch tablet. The goal acquisition task involves using the touch tablet to obtain a goal word using either a menu-selection or scrolling access strategy. The purpose of the study is to determine the relative efficiencies of the access strategies, but there will be no direct benefit to you.

All of the data collected will be kept strictly confidential. There will be no risk to you and your name will not be associated with your data. You will be given a copy of this consent form to keep.

This experiment will take approximately one hour. You are free to withdraw from the experiment at any time, but then you will not receive the 4 points of extra credit. If you have any questions, please ask the experimenter now. If you have any additional questions later, you may reach Sarah Osgood at 677-5176 or 677-5295.

______________________________ ______________
signature of participant date

______________________________ ______________
signature of researcher date

Appendix B

Word Familiarity Rating Forms

Preliminary Word Familiarity Rating Form

1 Have never heard of the word.

2 Have heard of the word, but do not know what it is.

3 Have heard of the word, and do know what it is.

If you answered "3", then is the word a:

BIRD	1	Flightless
	2	Perching
	3	Prey
	4	Sea
	5	Water Fowl
FISH	6	Diadromous (Fresh/Salt Water)
	7	Fresh Water
	8	Open Ocean
	9	Reef Inhabitant
INSECT	10	Carnivorous
	11	Herbivorous
	12	Omnivorous
	13	Scavenger
MAMMAL	14	Hoofed
	15	Pouched
	16	Primate
	17	Rodent
	18	Toothless

Final Word Familiarity Rating Form

1 Have never heard of the word.

2 Have heard of the word, but do not know what it is.

3 Have heard of the word, and do know what it is.

If you answered "3", then is the word a:

BIRD	1	Bird of Prey
	2	Songbird
	3	Tropical
	4	Water Fowl
FISH	5	Diadromous (Fresh/Salt Water)
	6	Fresh Water
	7	Open Ocean
	8	Reef Inhabitant
INSECT	9	Carnivorous
	10	Herbivorous
	11	Omnivorous
	12	Scavenger
MAMMAL	13	Hoofed
	14	Pouched
	15	Primate
	16	Rodent

Appendix C

Ratings of Goal Words

Familiar Goal Words

Goal Word	N	Correct Main Category	Incorrect Descriptive Category	Correct Descriptive Category
American Eel	20	14	11	3
Angelfish	20	14	12	2
Ant	20	20	11	9
Ape	20	20	0	20
Barracuda	20	11	6	5
Bass	20	19	2	17
Cardinalfish	20	12	10	2
Catfish	20	19	9	10
Cockroach	20	19	1	18
Deer	20	20	0	20
Duck	20	18	3	15
Eagle	20	20	4	16
Flea	10	10	1	9
Goose	20	20	3	17
Grasshopper	20	20	0	20
Hawk	20	20	1	19
House Fly	20	20	2	18
Kangaroo	20	20	0	20
Koala	20	15	7	8
Locust	20	20	5	15
Maggot	10	10	0	10
Meadowlark	10	10	0	10
Monkey	20	19	1	18
Mosquito	10	10	2	8
Mouse	20	19	0	19
Parrot	10	10	1	9
Robin	10	10	0	10
Shark	20	19	6	13
Sheep	20	20	0	20
Squirrel	20	20	3	17
Sturgeon	20	8	4	3
Toucan	10	10	1	9

Unfamiliar Goal Words

Goal Word	N	Correct Main Category	Incorrect Descriptive Category	Correct Descriptive Category
Alewife	20	2	2	0
Aye-Aye	20	1	0	1
Bowfin	20	6	4	2
Bunting	20	1	1	0
Carrion Beetle	20	7	5	2
Cavy	20	0	0	0
Chamois	20	1	1	0
Chinch Bug	20	4	2	2
Cicada Killer	20	4	3	1
Earwig	20	3	0	3
Gnus	20	4	4	0
Honeycreeper	10	5	4	1
Junco	20	2	0	2
Lacewing	20	2	2	0
Lemur	20	6	3	3
Manta	20	4	1	3
Merganser	10	3	0	3
Merlin	10	3	2	1
Mudwinnow	20	2	0	2
Osprey	10	5	2	3
Parrotfish	20	6	2	4
Phalanger	20	0	0	0
Quetzel	10	1	1	0
Scaup	10	2	1	1
Scorpionfish	20	15	13	2
Scorpion Fly	20	7	5	2
Shad	20	1	1	0
Skate	20	4	4	0
Stink Bug	20	8	6	2
Vole	20	1	1	0
Walking Stick	20	9	3	6
Wallaby	20	4	0	4

Appendix D

Instructions for the Menuing Condition

The task involves using the touch tablet to obtain a goal word displayed on a computer screen. Move the index finger of the dominent hand to position the cursor on the display screen.

The goal word will be displayed in the upper corner of the screen and will remain there throughout the trial.

There are 3 levels of information in the menu structure: the main categories (1st level), descriptive subcategories (2nd level), and specific animal names (3rd level). The goal word will always be located in the 3rd level, that is, a specific animal name.

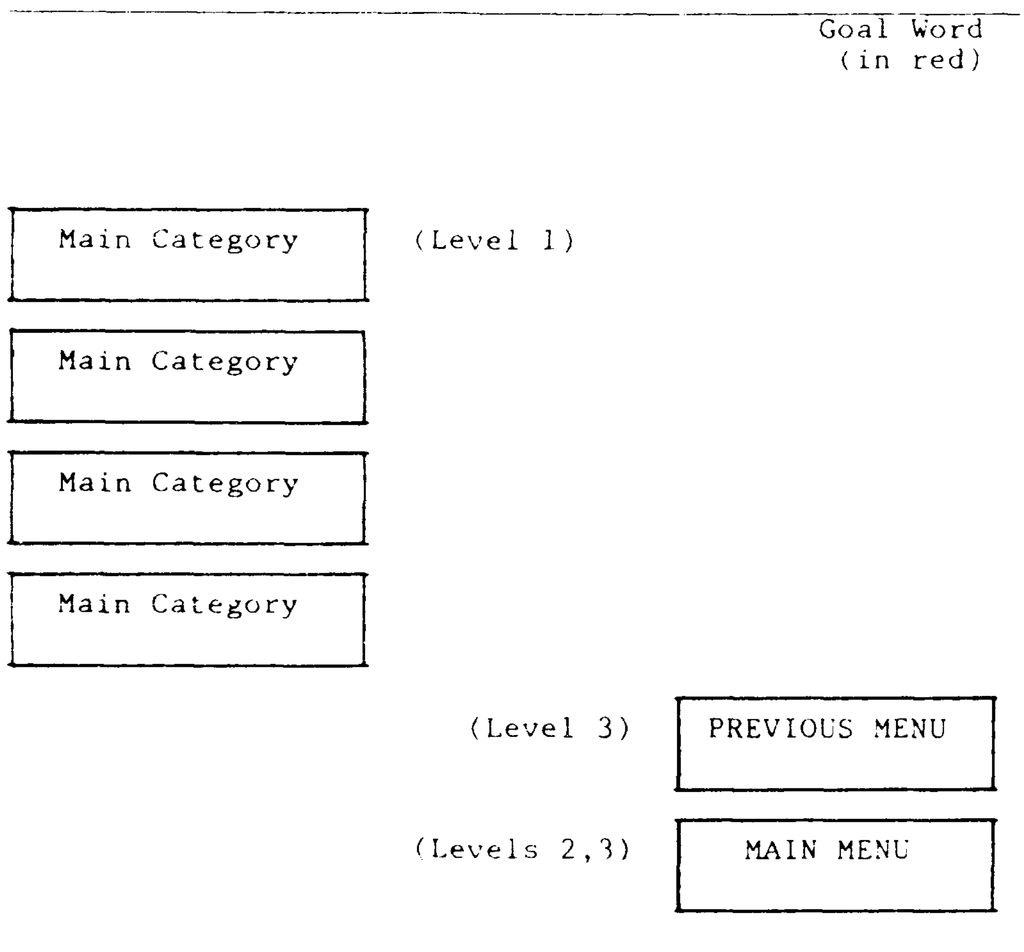
Use the "buttons" to maneuver within the menu structure. "PREVIOUS MENU" will display the words from a higher level. "MAIN MENU" will display the 1st level main categories. To select the goal word, press the button displaying the specific animal name.

Since you will be timed on how long it takes you to find and select the goal word, work as quickly and as accurately as possible.

There will be 64 trials with a short rest period between trials.

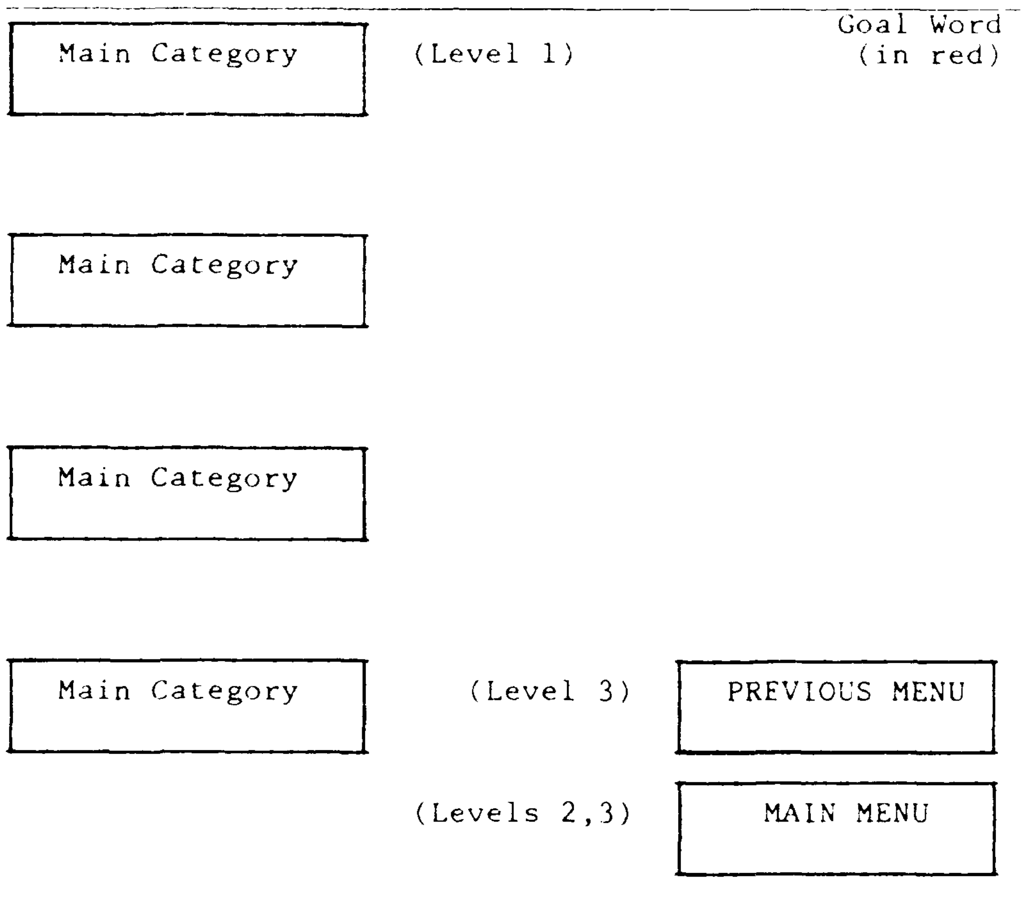
Appendix E

Menuing Display Layout for the 12 Line Menuing Condition



Appendix F

Menuing Display Layout for the 24 Line Menuing Condition



Appendix G

Questionnaire for Menuing Condition

Subject Number ____

Are you a biology major? Yes ____ No ____

Describe your "exposure" to each of the areas below. For example, are you a fisherman, bird-watcher, insect collector, hunter, etc.? Do you watch nature shows on TV? Have you done reading in any of the areas for school or in your spare time?

BIRDS ____

____

FISH ____

____

INSECTS ____

____

MAMMALS ____

____

How many computer courses have you had? ________

Briefly describe your previous experience with menuing and menu structures.

____

____

Appendix H

Instructions for the Scrolling Conditions

The task involves using the touch tablet to obtain a goal word displayed on a computer screen. Move the index finger of the dominent hand to position the cursor on the display screen.

The goal word will be displayed in the upper corner of the screen and will remain there throughout the trial.

Stop the scrolling function by touching the "PAUSE" buttom when you see the goal word or think you're close. Use the "FORWARD" and "BACKWARD" buttons to position the cursor on the row with the goal word in it. Then use the "SELECT ITEM" button to select the goal word.

Since you will be timed on how long it takes you to find and select the goal word, work as quickly and as accurately as possible.

There will be 64 trials with a short rest period between trials.

Appendix I

Scrolling Display Layout for the 12 Line Scrolling Condition

			Goal Word (in red)
	Descriptor	Goal Word	
		Goal Word	
		Goal Word	
		Goal Word	
Main Cat.	Descriptor	Goal Word	PAUSE
		Goal Word	
		Goal Word	
		Goal Word	
	Descriptor	Goal Word	FORWARD
		Goal Word	
		Goal Word	
		Goal Word	BACKWARD
			SELECT ITEM

Appendix J

Scrolling Display Layout for the 24 Line Scrolling Condition

Main	Descriptor	Goal Word	Goal Word
Cat.		Goal Word	(in red)
		Goal Word	
		Goal Word	
	Descriptor	Goal Word	
		Goal Word	
		Goal Word	
		Goal Word	
	Descriptor	Goal Word	
		Goal Word	PAUSE
		Goal Word	
		Goal Word	
	Descriptor	Goal Word	
		Goal Word	FORWARD
		Goal Word	
		Goal Word	
Main	Descriptor	Goal Word	
Cat.		Goal Word	BACKWARD
		Goal Word	
		Goal Word	
	Descriptor	Goal Word	
		Goal Word	SELECT
		Goal Word	ITEM
		Goal Word	

Appendix K

Questionnaire for Scrolling Conditions

Subject Number _____

Are you a biology major? Yes _____ No _____

Describe your "exposure" to each of the areas below. For example, are you a fisherman, bird-watcher, insect collector, hunter, etc.? Do you watch nature shows on TV? Have you done reading in any of the areas for school or in your spare time?

BIRDS ____

____

FISH ____

____

INSECTS ____

____

MAMMALS ____

____

How many computer courses have you had? __________

Briefly describe your previous experience with scrolling.

____

____

Did you use the left column (e.g., BIRD, FISH) of information to help you search for the goal word?
Yes _____ NO _____

Did you use the middle column (e.g., Tropical, Open Ocean, Rodents) to help you search for the goal word or did you just scan the right column consisting of the list of goal words?

____